School for Additive Manufacturing

iPeG

Algorithmic Individualization of Hip Endoprostheses

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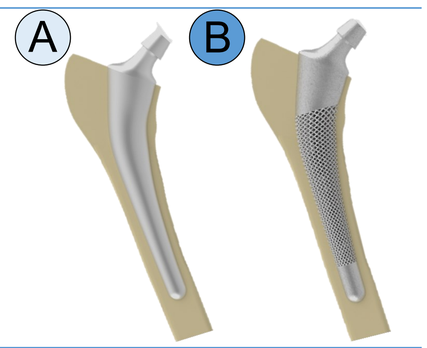
Project goals

Design of a Computer-Aided Engineering Environment (short: CAEE) for automated individualization of implants (using the example of a hip shaft endoprosthesis):

A Derivation of a generic process chain for **algorithmic individualization of the implant (shape)**

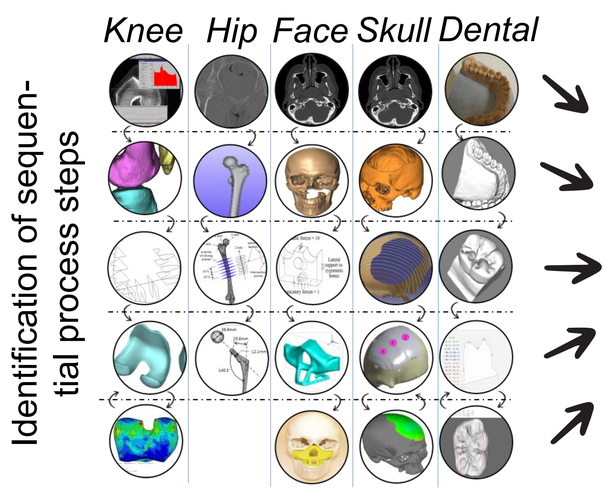
B Implementation of printed effects for **algorithmic individualization of the implant topology**



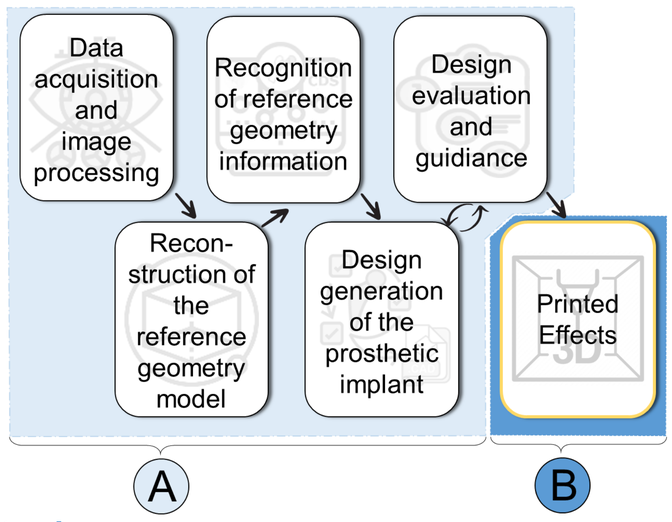
Methods and Materials

Systematic literature review

Manual and semi-automated process chains from related work



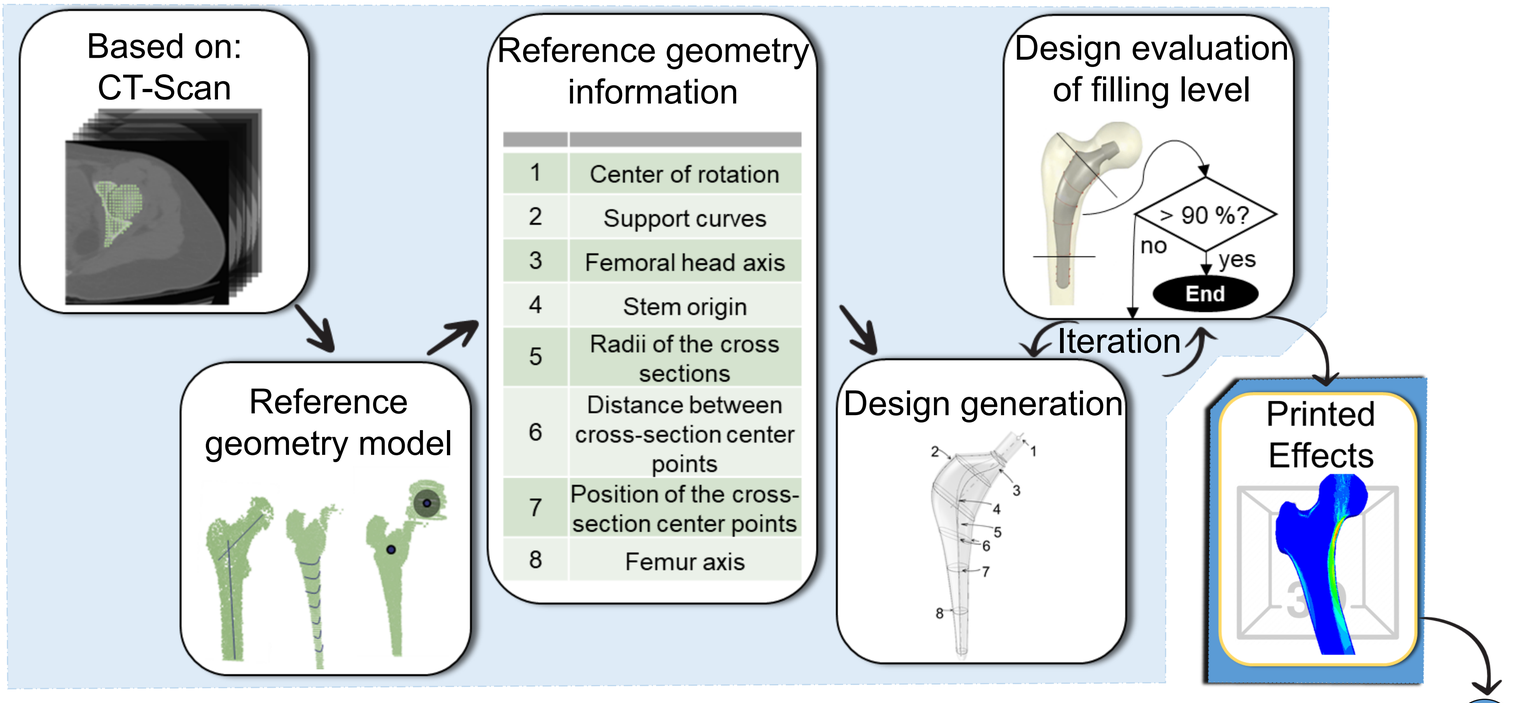
Derived generic process chain



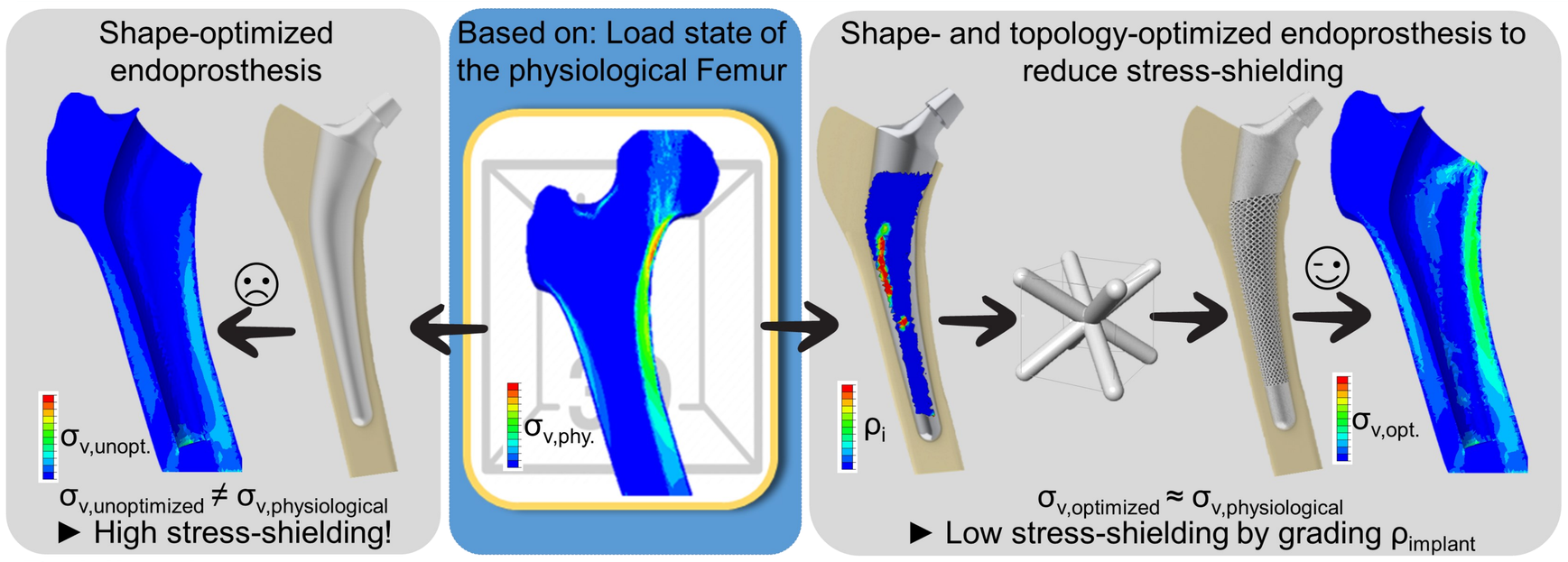
- Operationalization of the characteristic features and requirements
- Formalization of the algorithmic individualization process using the methodological framework of Computational Design Synthesis (CDS) in a CAEE

A Algorithmic individualization of the implant shape

- Increase of the filling level of the implant in the medullary canal by 30 % compared to a prefabricated endoprosthesis
- Complete preservation of healthy bone tissue
- Automated reconstruction and adjustment of the hip anatomy in case of deformities



Algorithmic individualization of the implant topology B



- Reduction of the stress-shielding up to 81 % through density-based topology optimization of the endoprosthesis compared to unoptimized

Publications

- Müller, P., Budau, J. P., & Gembarski, P. C. (2023). Development of an algorithm-based approach for Computational Design Synthesis of individualized implants. In Procedia CIRP (Vol. 119, pp. 1091–1096). Elsevier BV. https://doi.org/10.1016/j.procir.2023.03.152
- Müller, P., Gembarski, P. C., & Lachmayer, R. (2022). Reasoning Mechanism for the Implementation of Computational Design Synthesis. In 2022 IEEE 26th International Conference on Intelligent Engineering Systems (INES). 2022 IEEE 26th International Conference on Intelligent Engineering Systems (INES). IEEE. https://doi.org/10.1109/ines56734.2022.9922623
- Müller, P., Gembarski, P. C., & Lachmayer, R. (2022). Density-Based Topology Optimization for a Defined External State of Stress in Individualized Endoprosthesis. In Proceedings of the Design Society (Vol. 2, pp. 533–542). Cambridge University Press (CUP). https://doi.org/10.1017/pds.2022.55
- Müller, P., Gembarski, P. C., & Lachmayer, R. (2021). Parametric Topology Synthesis of a Short-Shaft Hip Endoprosthesis Based on Patient-Specific Osteology. In Towards Sustainable Customization: Bridging Smart Products and Manufacturing Systems (pp. 669–676). Springer International Publishing. https://doi.org/10.1007/978-3-030-90700-6_76

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Funded by the Lower Saxony Ministry for Science and Culture (MWK)